CONFIGURING A17802 AND A17803

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INTRODUCTION

The A17802 (analog sine/cosine output) and A17803 (digital output) are high-performance inductive position sensors with advanced digital compensations that maximize accuracy. This application note describes:

- Recommended baseline register settings
- Compensations available
- Compensation usage strategies
- How to calibrate and program compensations

CONTENTS

RECOMMENDED BASELINE REGISTER SETTINGS

The A17802 and A17803 (A17802/3) contain nonvolatile EEPROM that stores configuration settings. This memory is preprogrammed by Allegro with default values that minimize the need for programming by the system implementer. The required programming depends on the application:

- For motor-position sensing, to achieve baseline performance, TX_DRV_TRIM, N_AVG_CYCLES_OGA, and D_TX_CK_PH_TRIM are the only registers that must be programmed.
- For linear-stroke or low-speed angle sensing, the offset autocalibration feature should be disabled by setting the OGA_ALL_DIS field to one. This action is recommended because the algorithm is designed to operate with continuously rotating targets driven by motors.
- The A17803 has the following digital output configurations:
  - A17803PLEATR-S is programmable with serial peripheral interface (SPI); data is also output over SPI.
  - A17803PLEATR-M is programmable with Manchester communication; the output protocol can be set to motorSENT, SENT, PWM, or ABI.
    - MotorSENT output protocol has configurable SENT mode (including triggered SENT or continuous SENT) and tick time, and has incremental resolution, pulse width, hysteresis, and edge type.
    - The SENT protocol has configurable SENT mode and tick time.
    - The PWM protocol has configurable carrier frequency and output range.
    - The ABI protocol has configurable resolution, pulse width, and hysteresis.

COMPENSATIONS AVAILABLE

The 17802/3 compensations listed in this section are grouped into two categories: automatic and programmable. The automatic compensations are enabled by default. If the static (i.e., hard-coded) programmable compensations are used, the programmed corrections are always active in operation.

Automatic Compensations

- Automatic Gain Selection (AGS): At power-up, the IC automatically determines the optimal RX gain setting, and that setting does not change as long as the IC remains powered. The gain setting chosen depends on the air gap between the coils and target. AGS can be disabled by the AGS_EN register.
- Offset Autocalibration: After the first mechanical revolution, the IC continuously calibrates the offset in the received signal to stabilize accuracy over temperature and air-gap variation.

Programmable Static Compensations

- Offset and Gain Trimming (OGT): This corrects for offset and amplitude mismatch between the two RX signals.
  - ☐ In motor-position sensing applications, OGT improves start-up accuracy; when the rotor is spinning after a number of cycles determined by N_AVG_CYCLES_OGA, the offset autocalibration algorithm supersedes the OGT offset compensation.
  - ☐ In linear-stroke or low-speed angle sensing applications, OGT improves overall accuracy.
- Quadrature Compensation: This corrects for phase mismatch between the two RX signals.
- Electrical Harmonic Compensation (EHC): This corrects periodic error that repeats each electrical cycle.
- Input Phase Compensation (Demodulation Trim): This must be performed as a baseline compensation to ensure correct demodulation of signals. It adjusts the phase delay in RX sampling to maximize the demodulated signal, which in turn also allows correction for phase delays introduced by ferromagnetic targets such as steel.
- Synchronization Compensation: This provides a time-shift of the output angle by up to ±256 μs in 0.5 μs steps. This compensation can be used to overcome signal transmission and data processing time, so that the angle data represents the real-time motor angle when the data is used.
- Zero-Angle Compensation: This applies an offset to the outputted angle such that any arbitrary target angle position can represent 0.000°. This provides flexibility for system implementers directly in the device to prevent the need for precise end-of-line target alignment or external adjustment in the system controller.

CALIBRATION STRATEGIES

Depending on the desired accuracy and tradeoff with end-of-line calibration time, the system implementer can opt for different levels of calibration complexity:

- **Baseline calibration** leverages automatic compensations.
- **Simple calibration** programs OGT coefficients with ease.
- **Advanced calibration** is needed to achieve highest accuracy with electrical harmonic compensations.

Baseline calibration and advanced calibration in dynamic conditions are compared in the example shown in Figure 1.

To apply calibration across systems, two options are available:

- Fixed calibration across systems: A one-time characterization study determines the programmable compensations to apply to all units. This method effectively eliminates systematic errors and simultaneously avoids a measurement-based end-of-line calibration, which might otherwise add cost.
- Unique calibration per system: After end-of-line assembly, each system is measured and receives unique programmable compensations. This approach maximizes accuracy and combats errors introduced by mechanical misalignment.

Typically, the zero-angle and electrical harmonic compensations benefit the most from unique calibration, while the other compensations can often use a fixed-calibration approach.

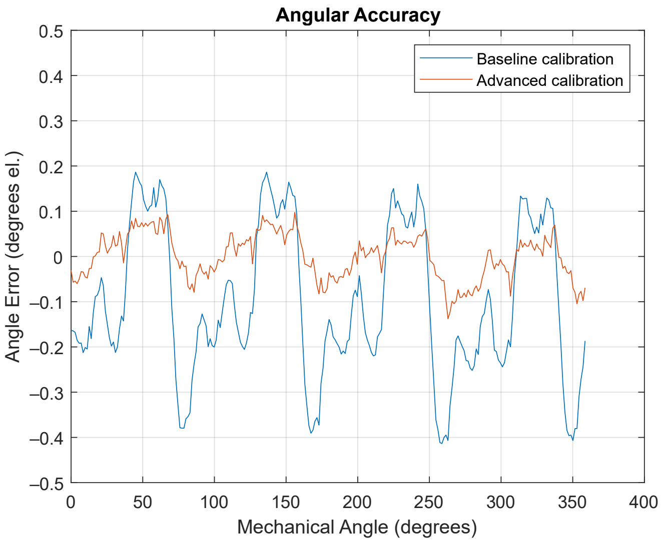

Figure 1: Comparison of accuracy on digital angle with baseline and advanced calibration in dynamic conditions (rotor spinning) with offset autocalibration enabled.

Baseline Calibration Procedure

Baseline calibration requires the following steps:

1. Mount the sensor printed circuit board (PCB) precisely in front of the target at the nominal air gap of the application.
2. Send the EEPROM access code 0xC418, immediately followed by 0x0E81, to the ACCESS field in direct memory register 0x1E. For instructions about how to write and read in the extended memory space, refer to the EEPROM and Shadow Memory Usage section of the datasheet.
3. Adjust EEPROM field TXDRV_TRIM (0x1C, bits [25:19]) to obtain approximately 5 volts peak-to-peak (Vpk-pk) between the TXP and TXN pins of the IC. Verify that the oscillating frequency is within the specified range (3 – 4 MHz). For more details, refer to the device datasheet.
4. For continuous rotary applications: Set the EEPROM field N_AVG_CYCLES_OGA (0x13, bits [24:22]) to the highest multiple of target teeth less than or equal to 16 (code 0 corresponds to the value 16). For more details, refer to the device datasheet.
5. Perform input phase compensation: Follow the procedure in the Input Phase Compensation section. This step is mandatory to ensure correct demodulation of signals before proceeding to any further static or automatic compensations.

Simple Calibration Procedure

Simple calibration is used to program the OGT coefficients, starting from the IC-calculated value for the OGA coefficients.

If the target can be rotated during the calibration procedure, simple calibration can also be used for noncontinuous rotary applications.

Simple calibration is performed as follows:

1. Perform baseline calibration steps.
2. Ensure that the offset autocalibration algorithm is enabled in EEPROM (OGA_ALL_DIS = 0).[1]
3. For A17802 if OGA_AMP_DIS (extended 0x25 bit [24]) is set to 0, IC has an obsolete factory settings and can be used for evaluation purposes only. Contact your Allegro sales representative for further questions.
4. Rotate the target steadily (without creating tilt or air-gap changes) for at least two times the electrical rotation corresponding to the N_AVG_CYCLES_OGA value (e.g., 30 electrical revolutions for N_AVG_CYCLES_OGA = 15).
5. Read-in the volatile memory from the following fields:
   - ☐ D_FE_SENS (0x51, bits [3:0])
   - ☐ OGA_Y_REF_AMPLITUDE (0x61, bits [16:0])
   - ☐ OGA_Y_OFFSET_COEFF (0x5C, bits [17:0])
   - ☐ OGA_X_REF_AMPLITUDE (0x5F, bits [16:0])
   - ☐ OGA_X_OFFSET_COEFF, (0x5E, bits [17:0])
6. Calculate the OGT parameters as follows[2]:

   Equation 1:

   ```
   OGT_X_OFFSET_C= toSignedFixed(Uncomplement2C(OGA_X_
   OFFSET_COEFF,18)/2^18/(D_FE_SENS+1),13,16)
   ```

   Equation 2:

   ```
   OGT_Y_OFFSET_C= toSignedFixed(Uncomplement2C(OGA_Y_
   OFFSET_COEFF,18)/2^18/(D_FE_SENS+1),13,16)
   ```

   Equation 3:

   ```
   OGT_Y_GAIN_C = toSignedFixed(OGA_X_REF_AMPLITUDE/
   OGA_Y_REF_AMPLITUDE -1 ,12,13);

   OGT_X_GAIN_C=0;
   ```

7. Write the calculated parameters to EEPROM at the following fields:
   - ☐ OGT_X_OFFSET_C (0x11, bits [12:0])
   - ☐ OGT_X_GAIN_C (0x11, bits [24:13])
   - ☐ OGT_Y_OFFSET_C (0x12, bits [12:0])
   - ☐ OGT_Y_GAIN_C (0x12, bits [24:13])

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[1] For A17803, ensure that OGA_OFF_DIS (extended address 0x25, bit [25]) is set to 0 and OGA_AMP_DIS (extended address 0x25, bit [24]) is set to 1; if they are not set properly, correct the EEPROM settings.
For A17802, if OGA_AMP_DIS (extended address 0x25, bit [24]) is set to 0, the IC has an obsolete factory settings and can be used for evaluation purposes only. For further questions, contact an Allegro sales representative.

[2] Code for MATLAB methods toSignedFixed and Uncomplement2C is reported in the Uncomplement2C Function section of the Appendix.

ADVANCED CALIBRATION PROCEDURE

The following describes how to collect data for and program the programmable compensations.

Data Acquisition

The optimal method to calculate compensation coefficients requires performing a discrete Fourier transform (DFT) on a set of samples acquired at unique angular positions. To perform an accurate DFT, there must be an accurate reference system with the capability to rotate the system's target to unique, equally spaced angular positions over a complete mechanical [3] rotation of 360°. If the intended end-of-line (EOL) calibration uses electrical harmonic compensation (EHC), there must be a sufficient number of angular positions, n, to resolve a fourth harmonic content in each electrical period. It is recommended that n angular positions be equal to 16 times the number of teeth, N_{Teeth}, of the target-coil system. Therefore, the angular step size, $\Delta\Theta$, is equal to 360°/n mechanical degrees, where $n = 16 \times N_{Teeth}$.

Sample Acquisition Procedure

To acquire angular position data for proper EOL calibration:

1. Mount the target in a system with an accurate rotary stage.
2. Mount the sensor printed circuit board (PCB) precisely in front of the target at the nominal air gap of the application. Ensure that any nonideal tilt in the PCB and/or target is minimized.

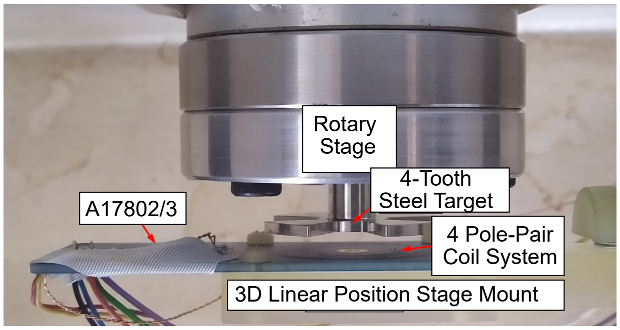

Figure 2: A17802/3 sensor board positioned in front of its target mounted on a high-precision rotary stage.

3. Send the EEPROM access code 0xC418, immediately followed by 0x0E81, to the ACCESS field in direct memory register 0x1E. For A17802, the IC must be repowered and the access code must be sent within 20 ms of power on. [4]
4. Adjust EEPROM field TXDRV_TRIM (0x1C, bits [25:19]) to obtain approximately 5 volts peak-to-peak (Vpk-pk) between the TXP and TXN pins of the IC. Verify that the oscillating frequency is within the specified range (3 – 4 MHz). The IC must be repowered in order to observe the effect of the changed value in EEPROM. After every repower, perform the memory access sequence detailed in step 3. For more details, refer to the device datasheet.
5. For continuous rotary applications, set the EEPROM field N_AVG_CYCLES_OGA (0x13, bits [24:22]) to the highest multiple of target teeth that is less than or equal to 16 (code 0 corresponds to the value 16). For more details, refer to the device datasheet.
6. Read all compensation fields in the table that follows. To ensure the EOL calibration is performed correctly, if any field does not equal 0x0, write all compensation fields with the value 0x0.

Compensation	Field Name		EEPROM Address
	X	Y	
OGT, Offset	OGT_X_OFFSET_C	OGT_Y_OFFSET_C	0x11,0x12
OGT, Gain	OGT_X_GAIN_C	OGT_Y_GAIN_C	0x11,0x12
EHC, Amplitude	EHC_X_H(i)_AMP [1]	EHC_Y_H(i)_AMP [1]	0x13:0x18
EHC, Phase	EHC_X_H(i)_PHASE [1]	EHC_Y_H(i)_PHASE [1]	0x13:0x18
ASC, Quadrature	ASC_QUAD_COMP		0x1B

[1] For each harmonic, i, including 2, 3, and 4.

7. Read the following EEPROM fields to verify each is enabled:
    a. AGS_EN (0x15, bit [21]) enables automatic front-end (FE) gain selection at startup. If disabled, FE gain is determined by EEPROM field FE_SENS_TRIM (0x15, bits [25:22]).
    b. EHC_HARM_WEIGHT_EN (0x18, bit [21]) enables the scaling of harmonic amplitude corrections with the input complex amplitude of the signals. When using harmonic compensation during typical operations, this bit must be enabled.

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[3] Calibration over a full mechanical rotation is recommended in order to average on the variations from one electrical period to the other caused by mechanical misplacements (in particular, with arc-shaped sensors).
It is also possible to perform calibration by acquiring samples on a single electrical period. In this case, in the reported equations, N_{teeth} should be considered to be equal to one.

[4] For instructions about how to write and read in the extended memory space, refer to the EEPROM and Shadow Memory Usage section of the datasheet.

Input Phase Compensation (Demodulation Clock Trim)

To optimize the signal-to-noise ratio for the application-specific target and inductance-capacitance (LC) tank characteristics, trim the phase-demodulation clock as follows:

1. Sweep the shadow memory field D_TX_CK_PH_TRIM (0x38, bits [25:22]) from 0 to 15, reading direct memory fields X_EHC and Y_EHC at each step. D_TX_CK_PH_TRIM is a two's-complement signed field on 4 bits.
2. The values for X_EHC and Y_EHC are represented in the form of two's complement on 16 bits. The MATLAB method, uncomplement2C, [5] can be called to return the uncomplemented value of the input signal, X_EHC or Y_EHC, on N_BITS as:
    - X_EHC = uncomplement2C(X_EHC, 16); and
    - Y_EHC = uncomplement2C(Y_EHC, 16).
3. Calculate the complex amplitude of signals with the uncomplemented X_EHC and Y_EHC for each trim value:

$$CA = \sqrt{X\_EHC^2 + Y\_EHC^2}$$

The resulting values should provide a curve similar to that shown in Figure 3. Write in the EEPROM field D_TX_CK_PH_TRIM (0x18, bits [25:22]) the trim value that provides the highest complex amplitude value.

There is a time-based delay on the demodulation clock. This delay is determined by D_TX_CK_PH_TRIM. Hence, the trim is frequency dependent. Ensure that the chosen trim is compatible with the frequency variation that might arise in application, such as frequency variation caused by air gap variation. For further information, refer to the datasheet.

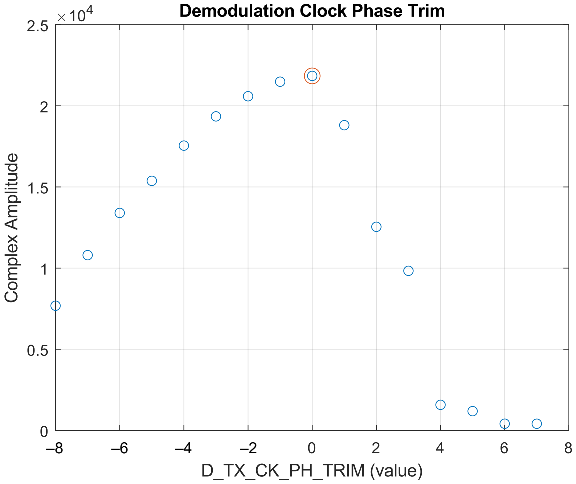

Figure 3: Complex amplitude is a function of the D_TX_CK_PH_TRIM signed value. In this case, the optimal value for trim is zero.

Reading and Storing Data for the Next Compensations

1. Repower the device and send the access codes as in the Sample Acquisition Procedure, step 3.
2. Temporarily disable the offset autocalibration algorithm by writing the shadow memory field OGA_ALL_DIS (0x32, bit [25]) to a value of 1.
3. Store the value returned when reading the volatile memory field D_FE_SENS (0x51, bits [3:0]). This value represents the current front-end gain setting.
4. If using the Alternative Data Acquisition Method for A17802, perform that procedure now. If not using the alternative method, continue to the next step.
5. Sweep the position of the target across the equally spaced n angular positions. At each position:
    a. Wait 10 µs.
    b. Read the direct-memory field X_EHC (0x10, bits [15:0]), and store the value in an array X at the index of the current position.
    c. Read the direct-memory field Y_EHC (0x11, bits [15:0]), and store the value in an array Y at the index of the current position.
6. The acquired X and Y array values are represented in two's complement on 16 bits. To calculate trim, parameter values must be uncomplemented. Similar to the Input Phase Compensation procedure, call the uncomplementing method on the X and Y arrays:
    - X = uncomplement2C(X, 16)
    - Y = uncomplement2C(Y, 16)

The arrays obtained should have a function of angular position with a sinusoidal shape similar to that shown in Figure 4, and values should be between –32768 and 32767.

The phase of X should lead the phase of Y (because a cosine signal leads a sine signal). If this is not the case, before performing harmonic-compensation calculations with DFT, reverse the order of array X and array Y to enable correct calculation of the harmonic phases.

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[5] This method is reported in the Uncomplement2C Function section of the Appendix.

Alternative Data Acquisition Method for A17802

The A17802 includes a test-mode to acquire [X_EHC, Y_EHC] sample values as analog samples. These analog samples replace the sample measurements obtained during the sweep-and-read step of the Reading and Storing Data for the Next Compensations procedure (step 4). This method is well-suited for fast acquisition in a motor rotating system with a high-precision encoder.

1. Install sensor in a rotating bench with a high-precision encoder.
2. Connect the SIN and COS differential outputs to a high-precision acquisition system. Use encoder signals for the sampling clock for the acquisition. Set up the acquisition to obtain equally spaced samples across one mechanical revolution.
3. Set shadow memory fields BLOCK_VOLATILE_OUTPUT and ASIL_EN to 0 (0x3F, bits [21] and [19]). This disables reporting of diagnostics on the analog output and enables use of test modes.
4. Set volatile memory field TM_EHC2DAC (0x71, bit [0]) to 1. This test mode feeds through the internal X_EHC, Y_EHC digital registers to the differential analog outputs COS and SIN, respectively.
5. Acquire and store differential analog output voltage levels SIN and COS at precisely equally spaced encoder-angle points along the mechanical period.
6. Convert COS to X and repeat for SIN and Y:

$$X = \frac{2^{15} \times SamplesCOS}{3}$$

   NOTE: A step to obtain uncomplemented values (see Reading and Storing Data for the Next Compensations, step 6), is not needed because the obtained values are already signed.

7. Verify the data collected are as described in the Reading and Storing Data for the Next Compensations procedure, step 6.

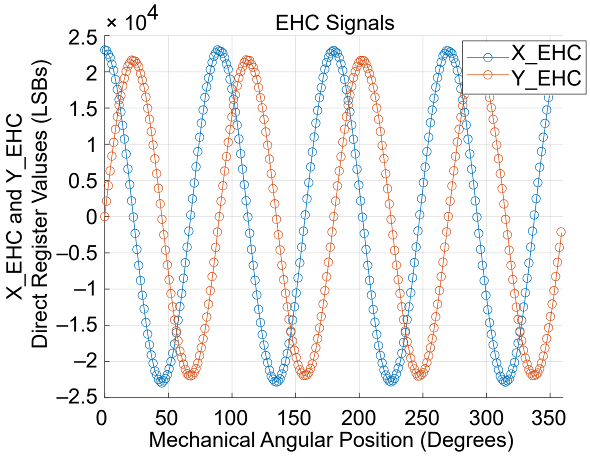

Figure 4: Values of X_EHC and Y_EHC in function of mechanical angle position.

Offset and Gain Trimming (OGT)

The A17802/3 compensates offset and gain nonidealities in the balance of clockwise and counterclockwise windings and between sine and cosine windings in the PCB coils directly at power-up with the OGT fields.

To program the OGT fields, the following procedure can be followed starting from the X and Y samples collected as described in the Sample Acquisition Procedure:

1. Perform a DFT on the X and Y uncomplemented values. For OGT, DFT needs to be calculated only up to the point of $N_{Teeth} + 1$. To perform harmonic trimming up to the fourth electrical harmonic, calculate DFT up to the point of $(4 \times N_{Teeth}) + 1$.
2. Calculate the OGT offset as:

$$OGT\_X\_OFFSET\_C = \frac{|X_{DFT}[0]|}{n \times (D\_FE\_SENSE + 1)}$$

   To obtain the value for the Y channel, substitute X_{DFT} with Y_{DFT}. The offset value scales with the FE gain value because this might change at power-up when AGS is enabled. A17802/3 rescales the applied value with the selected FE gain.

3. Calculate OGT gain as:

$$OGT\_X\_GAIN\_C = \frac{1}{2}\left(\frac{|Y_{DFT}[N_{teeth}]|}{|X_{DFT}[N_{teeth}]|} - 1\right)$$

   To obtain the value for the Y channel, switch X_{DFT} with Y_{DFT}, and Y_{DFT} with X_{DFT}.

Prior to writing in EEPROM, all calculated values for trimming parameters must be converted to a fixed-point representation. The fixed-point method is a way to represent fractional (noninteger) numbers: Numbers must be unsigned or signed and must have a specified numeric fractional length (FL). The word length (WL) of the field determines how many bits, starting from the LSB, are stored in EEPROM. Signed fixed-point numbers are represented in two's complement.

The methods toUnsignedFixed and toSignedFixed are reported in the Fixed-Point Representation Functions section of the Appendix. The OGT fields type, word length, and fixed length are indicated in the table that follows.

Fields	Type	WL	FL
OGT_X_OFFSET_C OGT_Y_OFFSET_C	signed	13	16
OGT_X_GAIN_C OGT_Y_GAIN_C	signed	12	13

4. Convert each OGT-calculated value to the fixed length representation:

```
ogt_x_offset_c_SF= toSignedFixed(ogt_x_offset_c,13, 16)
ogt_x_gain_c_SF= toSignedFixed(ogt_x_gain_c, 12, 13)
```

   Repeat for Y values.

5. Write the calculated parameters to EEPROM at the following fields:
   - OGT_X_OFFSET_C (0x11, bits [12:0])
   - OGT_X_GAIN_C (0x11, bits [24:13])
   - OGT_Y_OFFSET_C (0x12, bits [12:0])
   - OGT_Y_GAIN_C (0x12, bits [24:13])

Electrical Harmonic Compensation and Quadrature Compensation

The A17802/3 can compensate for electrical harmonic distortion in the input signals due to the nonidealities of coil design, coil fabrication, and field uniformity across the coil surface. Compensation for the second, third, and fourth electrical harmonics can be made on the input signals. A quadrature compensation is also integrated to compensate for any deviation from quadrature between the sine and cosine electrical inputs due to nonideal design or PCB fabrication.

To program the EHC and quadrature fields, use the X_{DFT} and Y_{DFT} values as follows:

1. Calculate the reference phase for the Y signal in order to remove the shift due to the reference encoder:

   $$phase_{ref} = arg(Y_{DFT}[N_{teeth}]) + \frac{\pi}{2}$$

2. Calculate the phase of each harmonic component using:

   $$\mathit{EHC\_X\_H(i)\_PHASE} = \frac{mod\,(arg(X_{DFT}[(i) \times N_{teeth}]) + \frac{\pi}{2} - (i) \times phase_{ref},\ 2\pi)}{2\pi}$$

   Repeat for (i) = 2, 3, and 4, and using Y_{DFT} for the EHC_Y_H(i)_PHASE.

3. The amplitude of the harmonic component scales with the amplitude of the fundamental electrical harmonic when field EHC_HARM_WEIGHT_EN is set to 1, as recommended. Hence, the amplitude of the first electrical harmonic and the gain applied in OGT trimming is taken into account by calculating EHC trim using:

   $$\mathit{EHC\_X\_H(i)\_AMP} = \frac{|X_{DFT}[(i) \times N_{teeth}]|}{|X_{DFT}[N_{teeth}]|}$$

   Repeat for (i) = 2, 3, and 4, and using Y_{DFT} for EHC_Y_H(i)_AMP.

   Calculate the quadrature compensation, with consideration for the deviation from quadrature between the fundamental harmonics of Y and X, as:

   $$\mathit{ASC\_QUAD\_COMP} = \frac{arg(X_{DFT}[N_{teeth}]) - arg(Y_{DFT}[N_{teeth}]) - \frac{\pi}{2}}{2\pi}$$

4. Convert the calculated values to fixed-length representations using the functions described in the Fixed-Point Representation Functions section of the Appendix, and considering the following representational parameters:

Fields	Type	WL	FL
EHC_X_H(i)_AMP EHC_Y_H(i)_AMP	unsigned	10	14
EHC_X_H(i)_PHASE EHC_Y_H(i)_PHASE	unsigned	11	11
ASC_QUAD_COMP	signed	10	14

5. Write the calculated parameters in EEPROM at the following addresses:
   - EHC_X_H2_AMP (0x13, bits [9:0])
   - EHC_X_H2_PHASE (0x13, bits [20:10])
   - EHC_X_H3_AMP (0x14, bits [9:0])
   - EHC_X_H3_PHASE (0x14, bits [20:10])
   - EHC_X_H4_AMP (0x15, bits [9:0])
   - EHC_X_H4_PHASE (0x15, bits [20:10])
   - EHC_Y_H2_AMP (0x16, bits [9:0])
   - EHC_Y_H2_PHASE (0x16, bits [20:10])
   - EHC_Y_H3_AMP (0x17, bits [9:0])
   - EHC_Y_H3_PHASE (0x17, bits [20:10])
   - EHC_Y_H4_AMP (0x18, bits [9:0])
   - EHC_Y_H4_PHASE (0x18, bits [20:10])
   - ASC_QUAD_COMP (0x1B, bits [24:15])

Zero-Angle and Rotation Direction

The A17802/3 includes the option of setting a zero-angle reference at any arbitrary electrical angle value:

1. Calculate zero angle trim, starting from the chosen angle in degrees electrical:

$$DEL\_ZERO\_ANGLE = \frac{Zero\ Angle}{360°}$$

2. Convert the calculated value to its fixed-length representation (type: unsigned; fractional length: 16; word length: 16):

```
del_zero_angle= toUnsignedFixed(del_zero_angle,16, 16)
```

3. Write the obtained value in EEPROM field DEL_ZERO_ANGLE (0x1C, bits [16:1]).

It is possible to change the output angle rotation direction with respect to the input signals by setting EEPROM field DEL_ANGLE_POL (0x1C, bit [0]).

Synchronization Compensation

The A17802/3 includes programmable latency compensation for any fixed latency, such as the duration of a digital output frame or the propagation delay of the position data from the sensor to the microcontroller.

Latency compensation in the range of ±256 µs can be represented in fixed-point notation (type: unsigned; fractional length: 9; word length: 10).

To program a latency compensation:

1. Calculate the trim starting from the desired compensation in microseconds:

```
del_sys_abs= toSignedFixed(latency_in_us/256,10, 9)
```

2. Write the value in EEPROM field DEL_SYS_ABS (0x1B, bits [9:0]).

Adjusting the Automatic Gain Selection (AGS)

The A17802/3 includes an option for automatic selection of the analog front-end gain at startup (AGS). AGS is enabled by setting the EEPROM field AGS_EN (0x15, bit [21]).

When the algorithm is enabled, analog-gain selection is performed once per power cycle, during the startup sequence. The IC internally calculates the complex amplitude of signals at the startup position and selects a gain that maximizes the input signals for the linear range of the analog-to-digital converter (ADC).

When offset due to direct coupling between the TX and RX coils is small and mechanical mounting has limited misalignment, tilt, or target run-out, the X and Y signal amplitudes—and, hence, the complex amplitude—are approximately constant over the mechanical period. In this case, the power-on position does not affect gain selection.

However, in some cases—typically, designs with C-shaped sensors or large mechanical tolerances—X and Y signals might be modulated over the mechanical period, as in the example in Figure 5. In this case, the gain selected by the AGS algorithm might vary depending on the startup position: If the IC is powered-on in a position with a smaller complex amplitude, the selected gain might be larger than the one selected in a larger-complex-amplitude position. This could lead to accuracy degradation in these positions and, in extreme cases, to saturation and consequential error flagging.

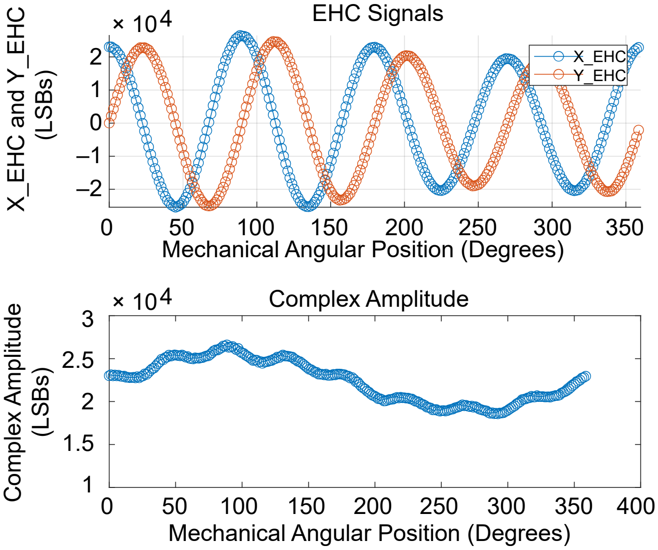

Figure 5: Values of X_EHC and Y_EHC in function of mechanical angle position in presence of large mechanical modulation (top); calculated complex amplitude (bottom).

To mitigate these issues, the A17802/3 offers the ability to reduce the chosen front-end (FE) gain by programming two different EEPROM fields:

- AGS_MAX_ROOM (0x16, bits [24:23]) adds a margin for the input complex amplitude used for gain selection.

AGS_MAX_ROOM	Additional Margin
0	0 mV
1	5 mV
2	15 mV
3	20 mV

- AGS_RANGE_ROOM (0x16, bits [22:21]) reduces the target range used for the front-end ADC for gain selection.

AGS_RANGE_ROOM	Range Reduction
0	0 %
1	10 %
2	15 %
3	20 %

The gain is selected using:

$$Gain = (ADC\ Range - AGS\_RANGE\_ROOM) / (Complex\ Amplitude + AGS\_MAX\_ROOM)$$

When front-end gain is selected, both the AGS_MAX_ROOM and AGS_RANGE_ROOM fields increase the room for offset or mechanical input modulation.

If a change occurs in the AGS_MAX_ROOM or AGS_RANGE_ROOM field, repeat the Reading and Storing Data for the Next Compensations procedure.

APPENDIX

Uncomplement2C Function

The following MATLAB method is used to extract the value from its 2’s complement representation.

```
function array_out=uncomplement2C(array_in, n_bits)

  range = (2^n_bits);
  threshold = range/2 - 1;
  array_out= double(array_in);

  for i=1:length(array_in)
    if array_out(i) > threshold
      array_out(i) = array_out(i) - range;
    end
  end
end
```

Fixed-Point Representation Functions

The following MATLAB methods can be used to convert a decimal value into its fixed-point representation.

```
function [value] = toUnsignedFixed(value, WL, FL)

 value=value*2^FL;
 value = round(value);
 if(abs(value) > 2^(WL))
 warning(‘OVERFLOW’);
 value= NaN;
 return;
 end

end
```

```
function [value] = toSignedFixed(value, WL, FL)

 value=value*2^FL;
 value = round(value);
 if(abs(value) > 2^(WL-1))
 warning(‘OVERFLOW’);
 value= NaN;
 return;
 end
 if value<0 % Take 2’s complement
 sign = (2^WL);
 value = value + sign;
 end

end
```

Revision History

Number	Date	Description	Responsibility
–	February 12, 2025	Preliminary	D. Palermo, E. Casu
1	December 1, 2025	Removed preliminary markings for release to general sales	E. Casu
2	April 8, 2026	Modified sections Recommended Baseline Register Settings (page 1), Compensations Available (page 2), Calibration Strategies (pages 3 and 4), and Advanced Calibration Procedure (page 5); Input Phase Compensation (pages 6 and 7) and made minor editorial modifications	E. Casu